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Pattern of Haematological Indices Among Pregnant Women at Booking in a Specialist Hospital in South-South Nigeria.

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Abstract

Background: Pregnancy is a physiological process that induces profound changes in haematological indices of women. Variations across trimesters have been observed. This study aimed to assess the effect of pregnancy on the haematological indices of pregnant women in a specialist hospital.
Materials and Methods: A quantitative, comparative, cross-sectional study was conducted at the antenatal clinic of Central Hospital, Agbor, Delta State, Nigeria. A total of 322 participants (242 pregnant and 80 non-pregnant) who consented participated. Blood samples were collected from them and analysed. The haematological indices were compared between the pregnant and non-pregnant groups, as well as among the three trimesters.
Results: The haematocrit (31.89±3.48 vs 35.02±3.59, P=0.001), lymphocytes (30.65±7.06 vs 47.37±9.00, P=0.001) and Mix (Basophil, Eosinophils, and Monocyte) (7.32±2.85 vs 8.56±2.27, P=0.001) were significantly lower in the pregnant group. Total white blood cell count (7.16±1.81 vs 5.94±1.51, P=0.001) and Neutrophils (62.25±8.59 vs 43.60±9.81, P=0.001) increased significantly in the pregnant cohort. Comparing across the three trimesters, there was a decrease in Haematocrit as pregnancy advanced, although it was not statistically significant. There was a significant reduction in haemoglobin (11.10 ± 1.00 vs 10.53±1.12, P=0.013) and lymphocyte (33.64±8.70 vs 30.31±6.90, P=0.017) levels between the first and second trimesters, as well as between the first and third trimesters (11.10±1.00 vs 10.41±1.12, P=0.02 and 33.64±8.70 vs 29.84±6.15, P=0.008). Neutrophil levels increased significantly between the first and second trimesters (58.63±9.12 vs 63.15±8.87, P=0.008), as well as between the first and third trimesters (58.63±9.12 vs 62.24±7.46, P=0.02). The prevalence of anaemia was 22.7%.
Conclusion: Pregnancy-related haematological changes can be mistaken for pathological conditions. Healthcare providers should be aware of and identify normal physiological changes to provide accurate assessments and effective management.

Keywords: Anaemia; Haematologic indices; Pregnant women; South-South Nigeria.

Introduction

Pregnancy is a physiological state that significantly affects various body organs and systems, including the haematological profile. The physiological changes are influenced by several factors, including socio-cultural and religious practices, genetics, environmental factors, and compliance with antenatal advice.[1-3] The haematologic system adapts to make provision for foetal haematopoiesis, ensuring adequate blood supply to the enlarged uterus and its content, thereby protecting both mother and foetus against the effects of impaired

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venous return in both the supine and erect positions, in addition to safeguarding against bleeding at delivery.[4] The plasma volume increases by 40 to 45% on average, and this increase is mediated by the direct action of progesterone and Oestrogen on the kidney, causing the release of renin and thus activation of the aldosterone-renin-angiotensin mechanism.[5-7] This leads to sodium retention and an increase in total body water. The adjustments that occur can be observed in haematological indices such as Haematocrit (HCT), haemoglobin (Hb) concentration, platelet (PLT) count, and white blood cell (WBC) count. While there is a decrease in Hb, HCT and PLT as a result of the physiological haemodilution that occurs in pregnancy, the total WBC and Neutrophil (NEUT) count are generally increased.[8-10] Red blood cell mass increases by 15–20% as a result of the increase in the production of erythropoietin.[11] As the increase in red cell mass is relatively smaller than that of plasma volume, the net result of Hb concentration falls by 1–2 g/dl. This is termed the physiological anaemia of pregnancy.[11,12] Although physiological, an abnormal haematological profile may affect pregnancy and its outcome. Anaemia and thrombocytopenia are the most frequent haematologic complications during pregnancy.[13,14]

Anaemia, defined as Hb concentration below 11.0 g/dl or a haematocrit concentration below 33% according to the World Health Organisation (WHO)[14], is the most common haematological issue during pregnancy.[15] Anaemia in pregnant women can significantly affect both the developing foetus and the mother. The consequences of anaemia can range from minor complications to severe health problems requiring immediate medical attention. It contributes to low birth weight and miscarriages and is a primary cause of reduced immunity in both the mother and the child, making them susceptible to various infections.[16] Malaria infection accounts for 3%–5% of maternal anaemia, and globally, around 50 million women are exposed to malaria, especially in highly endemic regions like Nigeria.[17-19] Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) are measurements related to red blood cells and are components of a complete blood count test. MCV measures the size of red blood cells, while MCH assesses the amount of Hb in an average RBC. MCHC indicates the concentration of Hb in an average red blood cell. These three measurements provide insight into the type of anaemia, such as Vitamin B12 and iron-deficiency anaemia in pregnancy. However, the values of these blood parameters have been observed to vary in studies.[1,20]

Pregnancy is a relatively hypercoagulable state with increased platelet activity and consumption.[21] The hypercoagulable state is a physiological preparation to ensure that blood loss at delivery is minimised. About 8–10% of pregnant women are affected by thrombocytopenia (PLT count < 150 × 109/L), particularly in the third trimester.[22,23] Approximately 75% of these cases are due to a benign process of gestational thrombocytopenia, which is mild and has no significance for the mother or foetus.[22,23] Increased consumption of PLT in the uteroplacental circulation has been suggested to be the explanation for the reduction in the number of circulating PLT.[22,23] The total WBC increase in pregnancy. The rise in WBC is due to the marginal increase in NEUT, which usually occurs from the second month of pregnancy, with an upward trend observed as pregnancy advances.[24]

As highlighted earlier, different factors affect the haematological changes in pregnancy. Agbor in Delta State, Nigeria, where this study was conducted, is a cosmopolitan community with diverse socio-cultural and religious practices. The need, therefore, to document local data derivable from pregnant women in this region is pertinent. By reviewing the haematological profile of this population, we hope to identify potential areas for intervention, inform evidence-based clinical practices, and contribute to the reduction of perinatal and maternal morbidity and mortality in the region.

Materials and Methods:

Setting: Central Hospital Agbor was established in the year 1906. It is a 250-bed hospital located in the South-South region of Nigeria. It provides general medical care and specialist services to indigenes of Delta State and neighbouring parts of Edo State. The Obstetrics and Gynaecology Department has two consultants who are fellows of the National Postgraduate Medical College of Nigeria and the West African College of Surgeons. The hospital

attracts a monthly antenatal booking of over two hundred women, and the delivery rate in the past 5 years has been approximately 1100/year. In November 2007, the Delta State Government introduced a free maternal health programme in the state. The intervention covers the cost of antenatal care, delivery including Caesarean Section (CS), postpartum and postnatal care up to six weeks after birth, as well as drugs, other supplies, laboratory investigations, and surgical management of ruptured ectopic pregnancy and blood transfusion. The programme has been maintained by successive governments to this day.

Study Design: This quantitative comparative cross-sectional study was conducted at the antenatal clinic of Central Hospital Agbor, Delta State, Nigeria, between January and February 2024.

Inclusion and Exclusion Criteria: The target population comprised all women who visited the antenatal clinic to book their pregnancies. The inclusion criteria included being confirmed pregnant, attending the antenatal clinic for booking, and signing informed consent. Healthy women of reproductive age who had not been pregnant in the last six months and consented to participate in the study were used as a comparison group with pregnant cohorts. Women with chronic medical conditions such as diabetes, chronic hypertension, sickle cell disease, and retroviral diseases were excluded from the study.

Ethical Consideration:

The study protocol was approved by the Ethical Committee of the hospital with ethical number AMZ/CHA/08/0014. Recruitment of study participants was by signing informed consent, after explaining the aim of the study in English, pidgin English or the local languages as appropriate. The study was executed following the guidelines of the Declaration of Helsinki, 2013.

Data collection: A semi-structured pretested interviewer-administered questionnaire was utilised to gather information on socio-demographic and obstetric characteristics, including the age of participants, tribe, level of education, religion, occupation, parity, and gestational age of the pregnancy. The questionnaires were administered by trained medical officers after obtaining informed consent. A total of 322 participants were recruited for the study, with 242 of them being pregnant women who presented during the study period and met the inclusion criteria. The authors are available and ready to supply the data on request.

Sample Size Calculation: All women presenting for ANC registration who consented were eligible to join the study. The prevalence of anaemia among antenatal women was used to calculate the sample size, as the haematocrit level remains one of the most common haematological parameters affected by pregnancy. The sample size was determined using the formula for sample size calculation for a cross-sectional study: $N=z^2pq/d^2$, where N is the required minimum sample size, Z is the value of test statistics (1.96), q is the probability of not being anaemic, that is, $(1-p)$, d is the degree of accuracy or standard error (0.05) at a 95% confidence interval, and p is the estimated prevalence of anaemia. A prevalence p = 86.4% was used based on a study conducted in Port Harcourt, Nigeria.[25] The calculated sample size was 180 participants. However, 242 pregnant women who presented within the study period and consented were recruited to increase the external validity of the study. We assume that this number will be evenly distributed across the trimesters. Eighty non-pregnant healthy women within the reproductive age group were recruited for comparison from healthy hospital staff and the Family planning clinic using a purposive non-consecutive sampling technique.

Sample Collection:

Three millilitres (3 ml) of venous blood samples were aseptically collected into labelled EDTA tubes for haematological analysis. The analysis was carried out using the Dymind DH36 haematology autoanalyser (Mindray, China). The DH36 is an automated haematology analyser designed for in vitro measurement of haematological parameters. It directly measures WBC, Hb, HCT, LYMPH, PLT, NEUT, MCV, MCH, MCHC, and the mixed cell population, which includes eosinophils, monocytes, and basophils (MIX). The analysis results were displayed after approximately 30 seconds, at which point the analyser produced a thermal printout of the results. The results were reviewed and entered into the second part of the questionnaire, which

contained the haematological profile of the participants.

Validation of the instrument

Standard operating procedures were strictly adhered to at each stage to ensure the quality of laboratory results. Standardisation, calibration of the instrument, and sample processing were carried out according to the manufacturer's instructions.

WHO haemoglobin concentration for the diagnosis and assessment of severity of anaemia was used to define and grade haemoglobin levels as follows: mild 10 - 10.9g/dl, moderate 7.0 - 9.9g/dl and severe less than 7g/dl.[26]

Statistical Analysis

Data were analysed using IBM Statistical Package for Social Science (SPSS) version 25. The demographic variables and haematological indices between cases and the non-pregnant group and between the three trimesters were compared using the Chi-square test and Student's T-test, with a $P<0.05$ as the significance level.

Results

The mean age of participants was 29.9 ±5.6 years, with a minimum and maximum ages of 18 and 49 years. The age groups 26-30 and 31-35 were in the majority, comprising 38.8 and 22.7% respectively. Nulliparous and multiparous groups were 45.7% and 49.4%, respectively, while only 5.0% were in the grand multiparous group. The study population were well educated with tertiary and secondary levels of education accounting for 44.7 and 46.6 % respectively. There was no significant difference in the sociodemographic characteristics between the pregnant women and the non-pregnant group. (Table I).

There were significant variations in the means of haematocrit levels in pregnant women compared to non-pregnant women ($p<0.05$). The difference in the mean haemoglobin levels between pregnant (11.00±6.55) and non-pregnant women (11.79±1.33) at the time of booking was not statistically significant(P=0.287). The mean MCHC of pregnant (33.15 ± 2.55) and non-pregnant (33.52 ± 1.42) women was statistically not significant (P=0.218). There were substantial decreases in the following measured parameters: haematocrit, lymphocyte, mixed cell population, as well as platelet counts, while the pregnant women recorded a statistically significant increase in total white blood cell (P=0.001) and neutrophil counts (P=0.001). (Table II).

There was no significant difference in the haematocrit levels across the three semesters. There was a significant decrease in haemoglobin from the 1st trimester to the second trimester and from the 1st

Table I: Sociodemographic characteristics of the pregnant women and the non-pregnant women

Variable	Pregnant N=242 (%)	Non-pregnant N=80 (%)	p-value
Age			
<20	11(3.4)	2 (0.6)	0.96
21-25	50(15.5)	6(1.9)	
26-30	90(28.0)	35(10.9)	
31-35	52(16.2)	21(6.5)	
36-40	33(10.3)	15(4.7)	
>41	6(1.9)	1(0.3)	
Parity			
Nullipara	109(33.9)	39(12.1)	0.463
Multipara	120(37.3)	39(12.1)	
Grandmultipara	14(4.4)	2(0.6)	
Religion			
Christians	230(71.4)	74 (23.0)	0.064
Moslems	8(2.5)	1(0.3)	
Others	4(1.2)	5(1.6)	
Tribe			
Ika	158(49.1)	56(17.4)	0.678
Igbo	27(8.3)	7(2.2)	
Hausa	29(9.0)	6 (1.9)	
Others	28(8.7)	11(3.4)	
Education			
None	7(2.1)	3(0.9)	0.159
Primary	17(5.3)	7(2.2)	
Secondary	117(36.3)	27(8.4)	
Tertiary	101(31.4)	43(13.4)	
Occupation			
Civil servants	21(6.5)	6(1.9)	0.342
Traders	147(45.7)	42(13.0)	
Home Managers	25(7.7)	7(2.2)	
Professionals	9(2.8)	6(1.9)	
Artisans	40(12.4)	19(5.9)	

Table II: Comparison of haematological Indices of pregnant and non-pregnant women

Variable	Pregnant	Non-Pregnant	p-value
HCT (%)	31.89 ± 3.48	35.02 ± 3.59	0.001*
HB (g/dl)	11.00 ± 6.55	11.79 ± 1.33	0.287†
MCV (fl)	86.42 ±1 0.04	83.30 ± 5.84	0.09*
MCH (pg/cell)	28.41 ± 2.56	28.22 ± 2.69	0.063†
MCHC (g/dl)	33.15 ± 2.55	33.52 ± 1.42	0.218†
WBC (x 10^9/L)	7.16 ± 1.81	5.94 ± 1.51	0.001*
NEUT (%)	62.25 ± 8.59	43.60 ± 9.81	0.001*
LYMP (%)	30.65 ± 7.06	47.37 ± 9.00	0.001*
MIX (%)	7.32 ± 2.85	8.56 ± 2.27	0.001*
PLT(x10^9/L)	210.62 ± 51.11	239.65 ± 59.88	0.001*

*Significant; † Not Significant: Values are Mean ± SD

Table III: Comparison of the Haematological values over the three trimesters in pregnant women

Variable	1st trimester	2nd trimester	3rd trimester	p-value (1st &2nd)	p-value (1st &3rd)	p-value (2nd &3rd)
HCT (%)	32.66±2.64	31.83±3.73	31.64±3.35	0.212†	0.11†	0.714†
HB (g/dl)	11.10±1.00	10.53±1.12	10.41±1.12	0.013*	0.02*	0.341†
MCV (fl)	83.39±9.20	87.00±10.94	86.92±8.66	0.075*	0.05*	0.977†
MCH (pg)	28.55±2.23	29.12±2.55	28.51±2.68	0.226†	0.95†	0.108†
MCHC(g/dl)	33.38±3.67	33.32±2.20	32.78±2.44	0.905†	0.303†	0.101†
WBC (10^9/L)	7.05±1.96	7.17±1.82	7.20±1.75	0.728†	0.685†	0.915†
NEUT (%)	58.63±9.12	63.15±8.87	62.46±7.46	0.008*	0.02*	0.566†
LYMPH (%)	33.64±8.70	30.31±6.90	29.84±6.15	0.017*	0.008*	0.622†
MIXED (%)	7.58±2.85	7.14±2.85	7.50±2.89	0.414†	0.883†	0.39†
PLT (x10^9/L	220.89±44.94	208.13±49.30	209.97±56.47	0.164†	0.31†	0.806†

*Significant; † Not Significant: Values are Mean ± SD

to the 3rd trimester among the study population. The MCV increased slightly as the pregnancy progressed, with a marginally significant increase between the 1st and 3rd trimesters. There were no significant changes in the mean values of MCH across the trimesters. MCHC levels remain consistent across the trimesters with no significant changes recorded.

The total WBC count showed no significant differences across the three trimesters. There was a significant increase in the neutrophil percentage from the 1st to the 2nd trimester and from the 1st to the 3rd trimester. Lymphocyte percentage shows a significant decrease from the 1st to the 2nd and 3rd trimesters. There was a decrease in the platelet counts; however, these were statistically not significant. (Table III)

The overall prevalence of anaemia was 22.7%, with mild, moderate and severe anaemia of 5.3%, 17.0% and 0.3% respectively. (Fig IV).

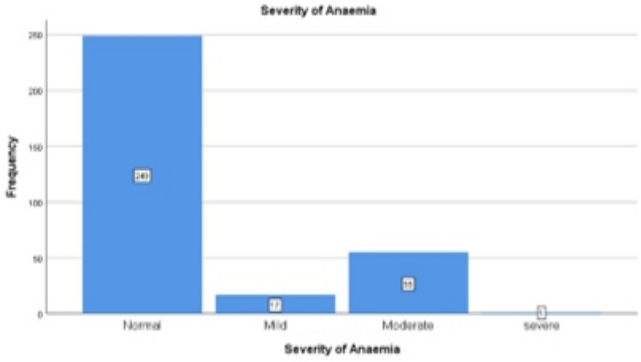

Figure I: Bar chart showing prevalence of Anaemia

Discussion

From the study, there was a significant decrease in HCT, LYMPH, MIX, and PLT counts in the pregnant individuals compared to non-pregnant individuals, while total WBC and NEUT counts were significantly higher in the pregnant cohort. These findings align with previous research studies.[2,22,28-31]

There was a progressive decline in the HB level between the pregnant women and the control and across the three trimesters, the difference was, however, not statistically significant. The finding is similar to the report by Kadas et al.[32] There was a significant decrease in HCT between the pregnant and non-pregnant (31.89± 3.48 vs 35.02± 3.59, P=0.001) and a progressive decrease across the three trimesters. This is similar to the findings in some previous studies.[28-32]

The gradual reduction in HCT and Hb levels observed across the three trimesters in pregnant subjects may be attributed to the escalating need for iron as pregnancy advances, driven by the increased requirements for foetal growth and a relatively larger Hb mass. The elevated levels of progesterone and oestrogen stimulate renal function, triggering the activation of the Aldosterone-Renin-Angiotensin system, leading to sodium retention and an increase in plasma volume. Despite the increase in red cell mass, the relative increase in plasma volume is higher, resulting in the physiological anaemia of pregnancy. Abnormal haematological profiles, though physiological, can compromise pregnancy outcomes, with anaemia and thrombocytopenia being the most prevalent haematological complications and key contributors to maternal mortality.[33]

It is estimated that more than 40% of pregnant women worldwide are anaemic, and at least half of this anaemia burden is assumed to be due to iron deficiency.[34] Pregnant women require additional iron and folic acid to meet their own nutritional needs as well as those of the developing foetus. Deficiencies in iron and folic acid during pregnancy can potentially negatively impact the health of the mother, her pregnancy, as well as foetal

development.[34] Evidence has shown that the use of iron and folic acid supplements is associated with a reduced risk of iron deficiency and anaemia in pregnant women. WHO recommends oral iron and folic acid supplementation with 30 mg to 60 mg of elemental iron and 400 µg daily (0.4 mg) folic acid for pregnant women to prevent maternal anaemia, puerperal sepsis, low birth weight, and preterm birth.[34]

MCV, MCH and MCHC are indices used to monitor and diagnose various conditions related to red blood cells. There was a significant increase in MCV between the first and third trimesters in this study. This is in keeping with the expected increase in red cell mass as the pregnancy advances. The MCH and MCHC did not change significantly. The degree of decrease in HCT and other red cell indices is dependent on factors such as geographical location, malaria, helminthic infection, diet and iron supplement intake.[32] Routine use of iron supplements by pregnant women has the potential to influence the various indices and ameliorate the effect of anaemia in pregnancy.

There was a significant increase in total WBC and NEUT between the pregnant and non-pregnant populations. Comparing the mean WBC within the trimesters, there was an increase in the mean absolute WBC within the trimesters, 7.05±1.96, 7.17±1.82 and 7.20±1.75, although it was not statistically significant. This pattern is in keeping with the increased WBC count with the trimester stages, as documented in some previous studies.[2,22,33]

The mean NEUT count in the first trimester was significantly lower than the second and third trimester (58.63±9.12 vs 63.15±8.87, P 0.008), (58.63±9.12 vs 62.46±7.46, P 0.02) while there was no significant difference in the NEUT values between the second and third trimester (63.15±8.87 vs 62.46±7.46, P 0.566). This confirms the finding by Luppi et al[35] that NEUT reaches significance at 13-28 weeks of pregnancy. It also agrees with the finding by Andrew et al[36] that NEUT rises in the first trimester up to the 30th week, after which the count remains steady.

The leucocytosis observed in pregnancy has been attributed to a series of immunological activities of an inflammatory response, selective immune tolerance, immunosuppression, and immunomodulation of the foetus.[28,37] Others have attributed the leucocytosis to an increase primarily in NEUT count, which may represent a response to stress due to the redistribution of the WBCs between the marginal and circulating pools.[22] Leucocytosis in the absence of infection is sometimes attributed to the physiological stressors of pregnancy, including pain, nausea, vomiting, and anxiety.[38] The Royal College of Obstetricians and Gynaecologists (RCOG) guideline states that a rising WBC count in pregnancy is not a reliable indicator of infection in subclinical chorioamnionitis; rather, a combination of clinical assessment, maternal blood tests (C-reactive protein and white cell count) and foetal heart rate should be used to diagnose chorioamnionitis in women with preterm premature rupture of membranes.[39]

A comparative analysis of LYMPH counts revealed a significantly higher mean value in control subjects compared to pregnant women (47.37± 9.00 vs 30.65±7.06, p-value 0.001). In pregnant women, a significant decline in LYMPH count was observed between the first and second trimesters (33.64±8.70 vs 30.31 ± 6.90, p-value 0.017) and the first and third trimesters (33.64±8.70 vs 29.84±6.13, p-value 0.008). However, no significant difference was found between the second and third trimesters (30.31±6.90 vs 29.84 ± 6.13, p = 0.622). Notably, this pattern of LYMPH decrease is in contrast to the observed trend in NEUT counts. This is similar to the report by Gebreweld et al.[33] These findings suggest that the fall in the level of lymphocyte reaches a nadir at the second trimester, while the reverse is the case for the neutrophil subpopulation.

Furthermore, a significant difference was found in MIX counts between pregnant women and non-pregnant controls (7.32±2.85 vs 8.56±2.27, p-value 0.001). Although a decrease in MIX count was observed in the second trimester compared to the first and third trimesters, it did not reach statistical significance. These findings are consistent with previous research by Kadas et al.[32] The findings suggest that there may be an initial decline in MIX count in early pregnancy, which becomes stable around the third trimester till delivery. However, some other studies reported no significant change.[28,33]

The mean PLT count in the pregnant women population was significantly lower than the nonpregnant control (210.62±51.11 vs

239.65±59.88, p-value 0.001). The finding is similar to the report by some previous authors.[28,29,32] There was no significant difference across the three trimesters. Pregnancy is a relatively hypercoagulable state with a resulting increased PLT activity and consumption.[21] This, combined with the haemodilution state, may lead to a mean platelet count that is slightly lower than that in the non–pregnant state.

The prevalence of anaemia was 22.7%, with mild, moderate or severe anaemia constituting 5.3%, 17.1% and 0.3%, respectively. This is lower than the prevalence of 36.7% reported by Omote et al[40] in Warri. It is lower than the 68.3% by Yusuf and Darma in Sokoto[41] and 50% and 47% in Lagos and Kano, respectively.[42] The lower incidence in our study may be due to sociocultural factors and dietary habits of the study population. WHO estimates that the prevalence of anaemia in pregnancy varies between 53.8% to 90.2% in developing countries and 8.3% to 23% in developed countries.[43] Anaemia remains a major contributor to maternal mortality. Iron and folic acid supplementation will go a long way in reducing the prevalence of anaemia.

Strengths and limitations: This study serves as pioneering research of its kind to emerge from this hospital and the surrounding locality. We expect it to serve as a foundational benchmark for future evaluations. The research was executed in a secondary healthcare facility that offers complementary antenatal care and delivery services, thereby encompassing a diverse sample of women from different socioeconomic strata. Nevertheless, a significant limitation of this study is that, due to its facility-based nature, it may not comprehensively represent the broader population. However, the study objectives were fulfilled and it has significantly contributed to knowledge in this area.

Conclusion: Pregnancy-related haematological changes can mimic abnormal values; therefore, healthcare providers must recognise and understand these pregnancy-related haematological changes to ensure accurate diagnosis, assessment, and management of pregnant women, thereby preventing misinterpretation and potential mismanagement.

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Authors' Contributions: Both authors contributed equally. Conceptualization and study design were by MNR. Data collection and analyses, drafting and review of the manuscript were done by the two authors, MNR and CNI. Both authors reviewed and approved the version for publication.

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